

# Study of lubricant degradation using PEEM

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## INTRODUCTION

With increasing storage density of magnetic media reaching (32 Gb/in<sup>2</sup> were recently announced for a demo by IBM) and increasingly smaller spacing between slider and disk surface approaching pseudo-contact, the interface between slider and disk becomes more and more important. Due to the small spacing there is a strong interaction between the hard carbon overcoat of the disk, the lubricant, and the surface of the slider, which often is also coated by amorphous hard carbon. Optimization of the tribological properties can only be obtained by considering the whole system and the interactions of the individual components. Tribochemistry plays a more important role for smaller spacings and thinner lubricants and protective overcoats [1]. Several methods have been applied to study the tribochemistry at the disk/slider interface. These methods include wear of disks in UHV while measuring the gaseous erosion products using a quadrupole mass spectrometer [2-4], thermal desorption studies by heating disks in UHV and recording the erosion products [5], and electron stimulated desorption [5]. These methods yield information about the gaseous erosion products removed from the disk but do not give information about the state of the remaining lubricant and possible chemical changes of the lubricant and disk or slider overcoat. Possible catalytic reactions caused by the presence of the slider surface were investigated by studying the reactions of perfluoropolyether (Z-DOL) in the presence of slider material Al<sub>2</sub>O<sub>3</sub>-TiC [6].

We have studied tribochemical processes between the hard carbon overcoat of the disk, the lubricant, and the carbon coated or uncoated slider surface using PEEM.

## ANTIOXIDANT ADDITIVES

In previous studies [7-10] we have applied PEEM to investigate tribochemical processes on hard disks and slider surfaces using the ability to acquire local NEXAFS spectra in wear tracks on disks and on selected areas of the slider surfaces such as wear marks or debris particles. We have tested disks with a variety of lubricants, worn with uncoated and carbon coated sliders, in ambient air or vacuum. All these test have shown one common result: If the wear test shows a failure of the disk (indicated by a sudden change in the coefficient of friction and visible wear marks) the lubricant in the wear track is oxidized. An additional peak at 288.5 eV appears in the carbon K edge spectra acquired in wear tracks that corresponds to carbon-oxygen bonds probably in carboxylic form. The appearance of this peak was observed under all conditions tested when a lubricant was present on the disk [7, 9]. It was confirmed that the carbon of the lubricant is oxidized and not the carbon of the protective hard carbon overcoat of the disk by wearing a disk without lubricant and performing NEXAFS in the wear track [7]. In this case no chemical modification was observed but a reduction in the total carbon signal due to a reduction of the carbon film thickness caused by the wear.

This result led to the development of new lubricants that contain two different antioxidants (AO#1 and AO#2) as additives to the standard disk lubricant perfluoropolyether (ZDOL). The additives are shown in Figure 1.

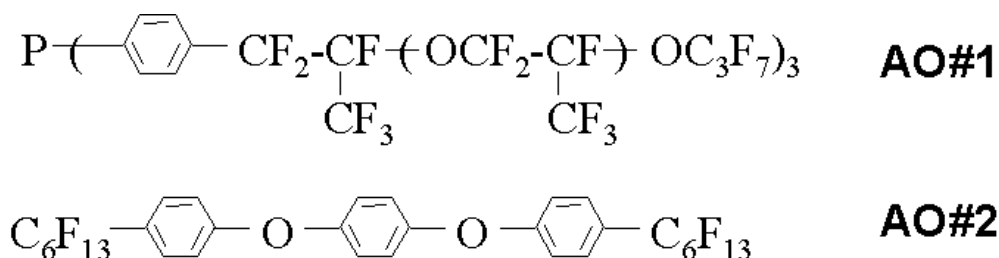


Figure 1: Antioxidants AO#1 and AO#2.

## WEAR TESTS

Wear durability was tested for disks lubricated with ZDOL 2000 in comparison to ZDOL 2000 containing 1% antioxidant AO#1 and AO#2. The wear test was performed in the UC Berkeley Computer Mechanics Laboratory tribochamber on disks with 7.5 nm CH<sub>x</sub> carbon overcoat and 1nm lubricant thickness, using an uncoated and a 7nm CH<sub>x</sub> coated slider with 2.5g preload and 0.1 m/s speed continuous drag test in UHV. Preliminary test showed an improved wear durability for tribotesting of the disks in vacuum in most cases [10]. Figure 2 shows detailed test results for the gaseous erosion products emitted from the disks during wear.

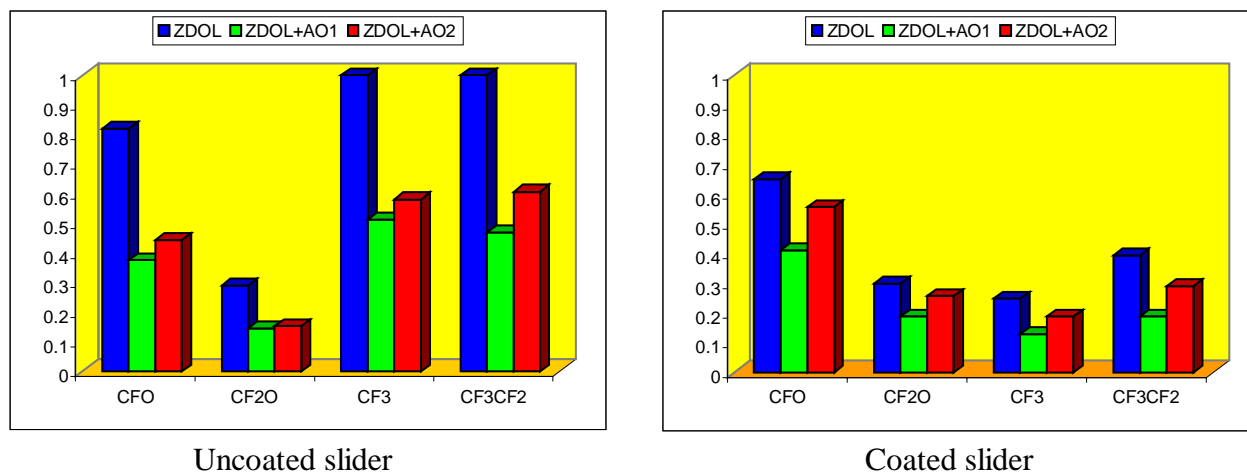


Figure 2: Relative intensity of gaseous erosion products during wear in UHV tribochamber of disk lubricated with ZDOL, ZDOL+AO#1, and ZDOL+AO#2.

The erosion products CFO and CF<sub>2</sub>O are characteristic for mechanical and thermal degradation while CF<sub>3</sub> and CF<sub>3</sub>CF<sub>2</sub> are characteristic for catalytic decomposition of the lubricant [2, 3]. The antioxidant additives reduce the emission of the erosion products in comparison to pure ZDOL, in particular for the uncoated slider case.

## PEEM STUDIES

The disks were studied using PEEM, and it was found that the antioxidants successfully prevent oxidation (Figure 3). The spectra in the wear tracks and outside the tracks are identical.

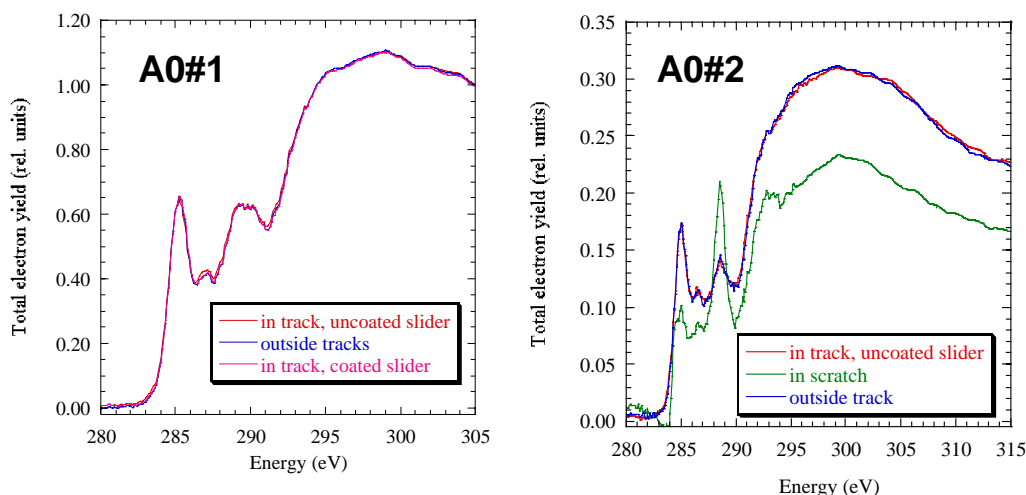


Figure 3: Local carbon K edge absorption spectra inside and outside wear tracks on hard disks lubricated with ZDOL+AO#1 and ZDOL+AO#2.

Oxidation is only observed if the wear is so strong that deep scratches are produced, the hard carbon overcoat is partially removed and the lubricant is probably removed completely. The disk lubricated with ZDOL without antioxidant showed again oxidation in the wear tracks and very strong oxidation in deep scratches.

The results obtained so far show the promising properties of lubricants containing antioxidants. Wear durability could be improved in some cases, and the catalytic decomposition of the lubricant was reduced and oxidation was prevented. This could lead to the development of new lubricants for modern extremely-high density storage media.

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